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[45] **Feb. 12, 1974**

[54] SIGNAL PROCESSING SYSTEM FOR READING INDICIA OVER A WIDE DEPTH OF FIELD

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[73] Assignee: **Servo Corporation of America**, Hicksville, N.Y.

[22] Filed: **Dec. 22, 1971**

[21] Appl. No.: **210,869**

[52] **U.S. Cl.235/61.11 E**, 235/61.7 R, 340/146.3 K, 250/219 D
[51] **Int. Cl.** **G06k 7/00**, G06k 7/10
[58] **Field of Search** .... 340/146.3 K, 172.5; 235/61.11 E, 61.7 R; 250/219 D, 220 R

[56] **References Cited**

UNITED STATES PATENTS

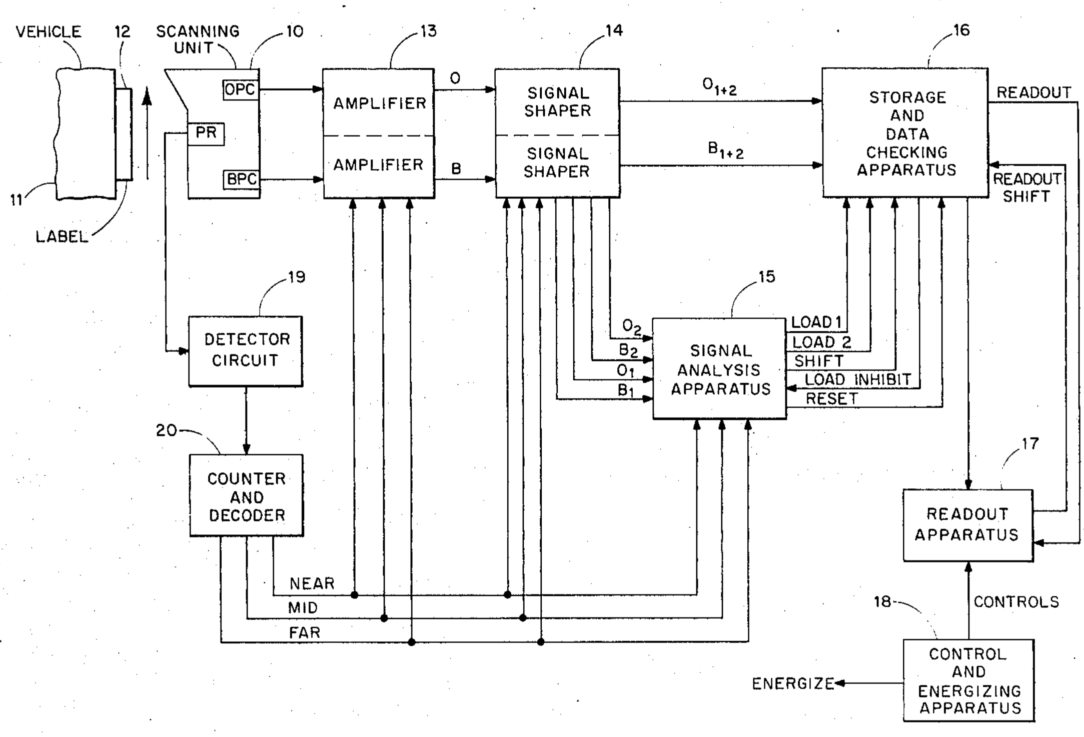
3,617,704	11/1971	Kapsambelis et al.	235/61.11 E
3,701,097	10/1972	Wolff	235/61.11 E

Primary Examiner—Thomas J. Sloyan
Attorney, Agent, or Firm—Kane, Dalsimer, Kane & Sullivan and Kurucz

[57] **ABSTRACT**

Automatic coded object identification system for reading labels of the type having retroreflective stripes arranged in a vertical array over a wide depth of field to two or more ranges (specifically three in the embodiment described herein). For each vertical scan of the stripes of a lebel by a scanner a set of electrical signals are produced. Each vertical scan also causes one of three processing control signals to be produced in succession. The electrical signals are amplified, shaped, and analyzed to determine if they meet prescribed limits as to pulse-width measurements for proper label-derived signals. The process control signals control the values of amplification, shaping, and pulse-width measurement limits so that during three successive scans three sets of signals from a label are processed in three different manners. Each of the three process control signals causes the apparatus to optimally process the signals for a label located within a corresponding one of the three ranges. Thus, if a label is within one of the three ranges, the signals produced during one of three scanning operations will be properly processed. When signals are properly processed and found to meet the prescribed limits of pulse-width and other timing criteria, they are stored in a shift register until all the signal data on the label is accumulated. The accumulated data is checked in accordance with pattern recognition and parity checking schemes and if determined to be proper label-derived data it is transmitted to read out apparatus.

5 Claims, 6 Drawing Figures



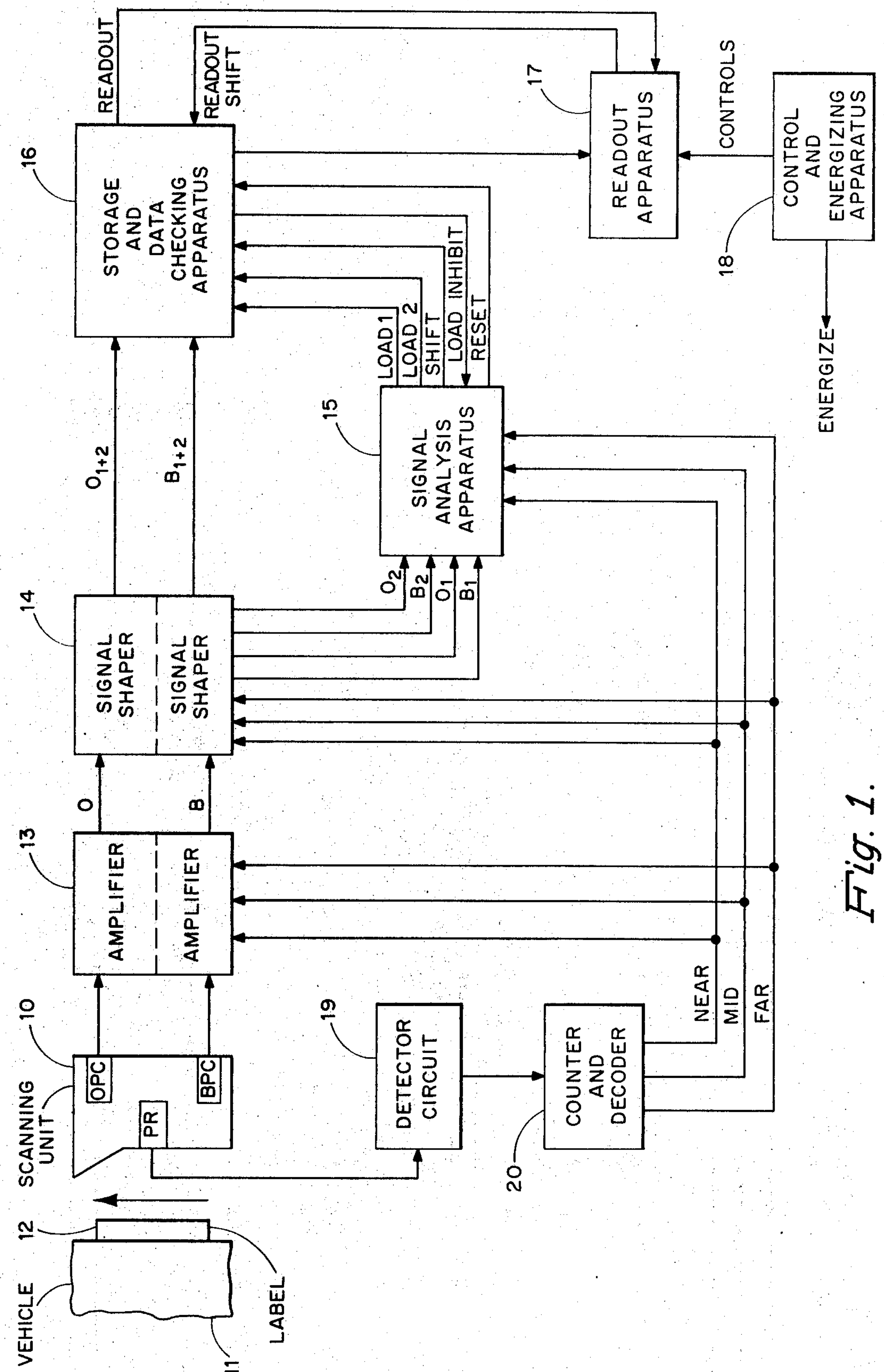

READOUT
READOUT SHIFT
17
READOUT APPARATUS
CONTROLS
CONTROL AND ENERGIZING APPARATUS
18
ENERGIZE
16
STORAGE AND DATA CHECKING APPARATUS
LOAD1
LOAD 2
SHIFT
LOAD INHIBIT
RESET
15
SIGNAL ANALYSIS APPARATUS
O1+2
B1+2
O2
B2
O1
B1
14
SIGNAL SHAPER
SIGNAL SHAPER
O
B
13
AMPLIFIER
AMPLIFIER
NEAR
MID
FAR
10
SCANNING UNIT
OPC
BPC
PR
19
DETECTOR CIRCUIT
COUNTER AND DECODER
20
12
VEHICLE
LABEL
11

Fig. 1.

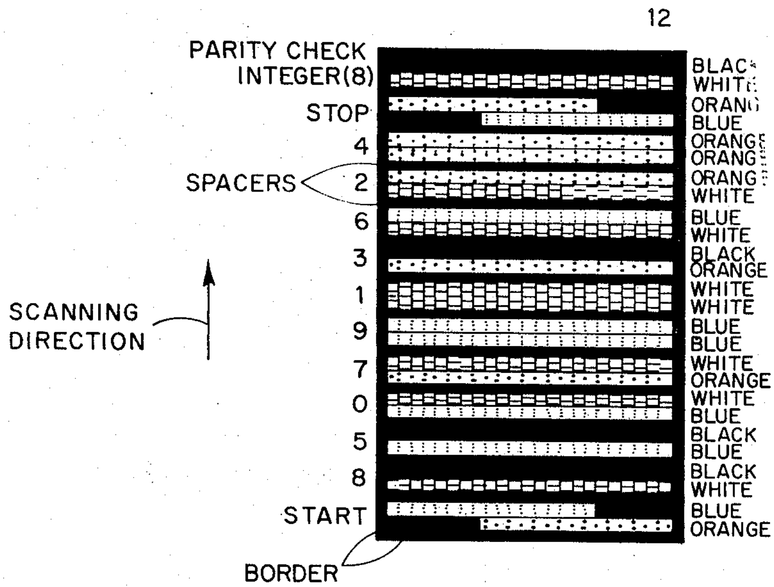

12
PARITY CHECK INTEGER(8)
STOP
4
SPACERS
2
6
3
1
9
7
0
5
8
START
BORDER
SCANNING DIRECTION
BLACK
WHITE
ORANGE
BLUE
ORANGE
ORANGE
ORANGE
WHITE
BLUE
WHITE
BLACK
ORANGE
WHITE
WHITE
BLUE
BLUE
WHITE
ORANGE
WHITE
BLUE
BLACK
BLUE
BLACK
WHITE
BLUE
ORANGE

Fig. 2.

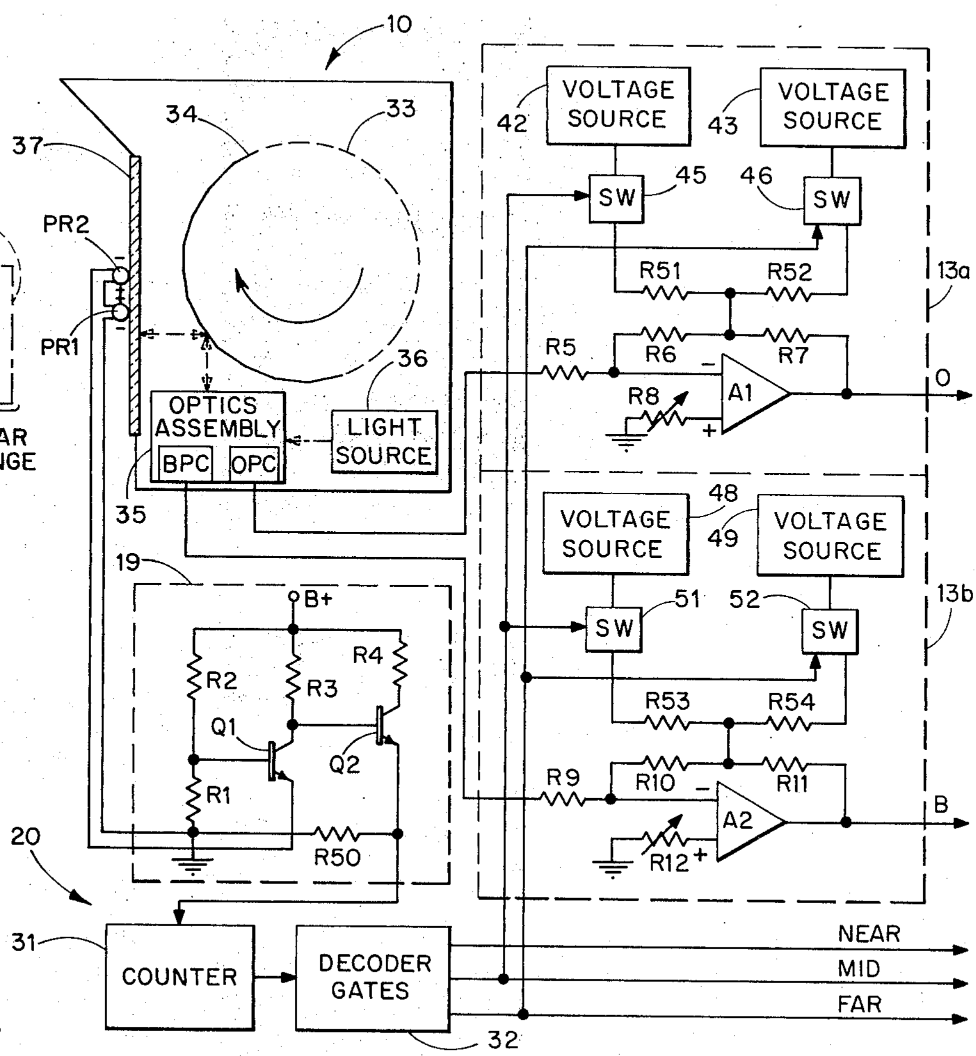

10
37
34
33
12
PR2
PR1
FAR RANGE
MID RANGE
NEAR RANGE
OPTICS ASSEMBLY
BPC
OPC
LIGHT SOURCE
36
35
19
B+
R2
R3
R4
Q1
Q2
R1
R50
20
31
COUNTER
DECODER GATES
32
VOLTAGE SOURCE
42
VOLTAGE SOURCE
43
SW
45
46
SW
R51
R52
13a
R5
R6
R7
R8
A1
O
VOLTAGE SOURCE
48
49
VOLTAGE SOURCE
SW
51
52
SW
13b
R53
R54
R9
R10
R11
A2
R12
B
NEAR
MID
FAR

Fig. 3.

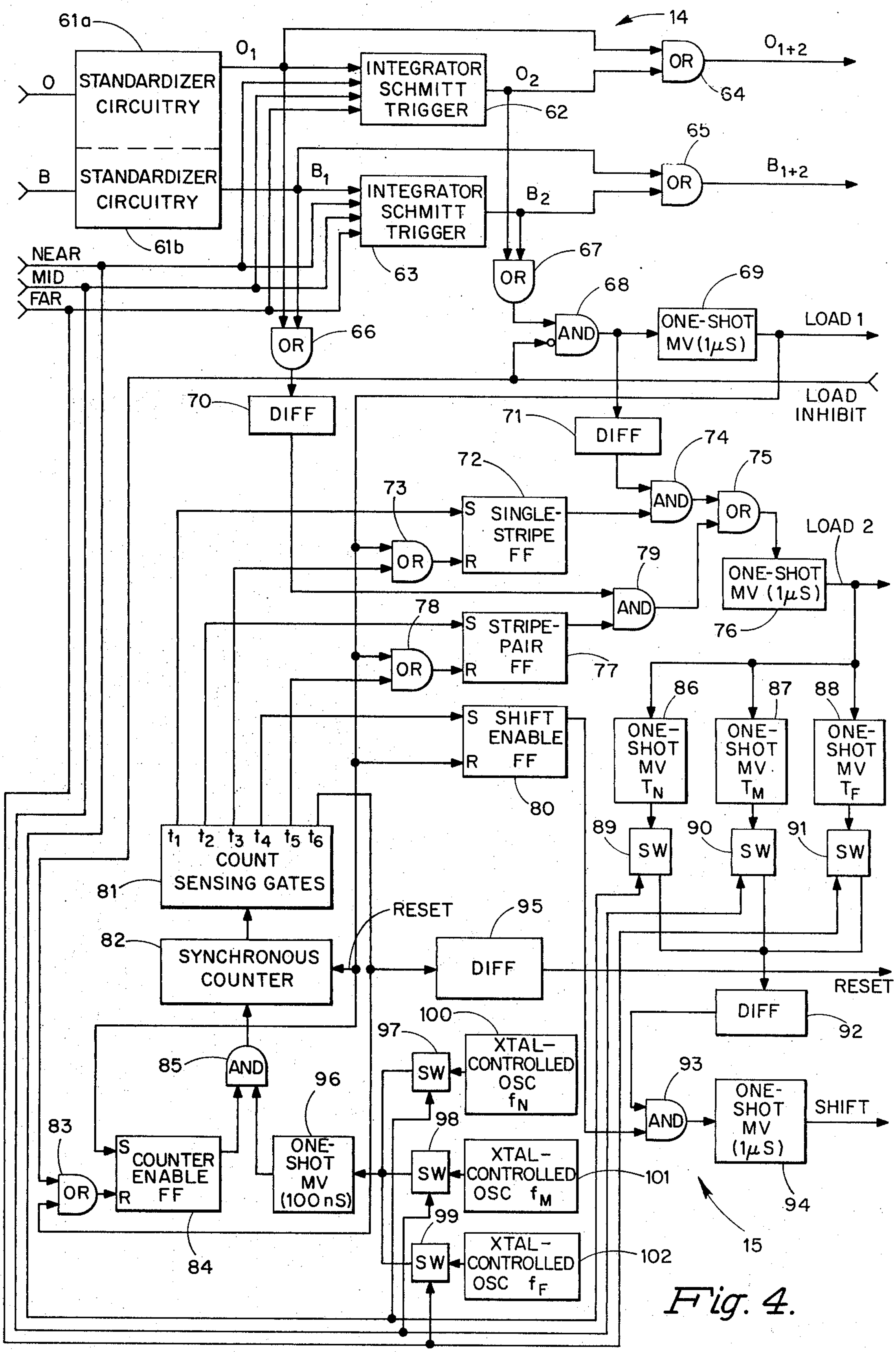

14
61a
O
B
STANDARDIZER CIRCUITRY
STANDARDIZER CIRCUITRY
61b
NEAR
MID
FAR
O1
B1
INTEGRATOR SCHMITT TRIGGER
INTEGRATOR SCHMITT TRIGGER
62
63
O2
B2
OR
64
65
O1+2
B1+2
OR
66
67
AND
68
ONE-SHOT MV(1μS)
69
LOAD 1
LOAD INHIBIT
DIFF
70
71
72
73
74
75
SINGLE-STRIPE FF
STRIPE-PAIR FF
SHIFT ENABLE FF
76
77
78
79
80
LOAD 2
ONE-SHOT MV (1μS)
ONE-SHOT MV TN
ONE-SHOT MV TM
ONE-SHOT MV TF
86
87
88
89
90
91
SW
t1 t2 t3 t4 t5 t6
COUNT SENSING GATES
81
82
SYNCHRONOUS COUNTER
RESET
95
92
93
94
SHIFT
83
84
85
COUNTER ENABLE FF
ONE-SHOT MV (100 nS)
96
97
98
99
100
101
102
XTAL-CONTROLLED OSC fN
XTAL-CONTROLLED OSC fM
XTAL-CONTROLLED OSC fF
15

Fig. 4.

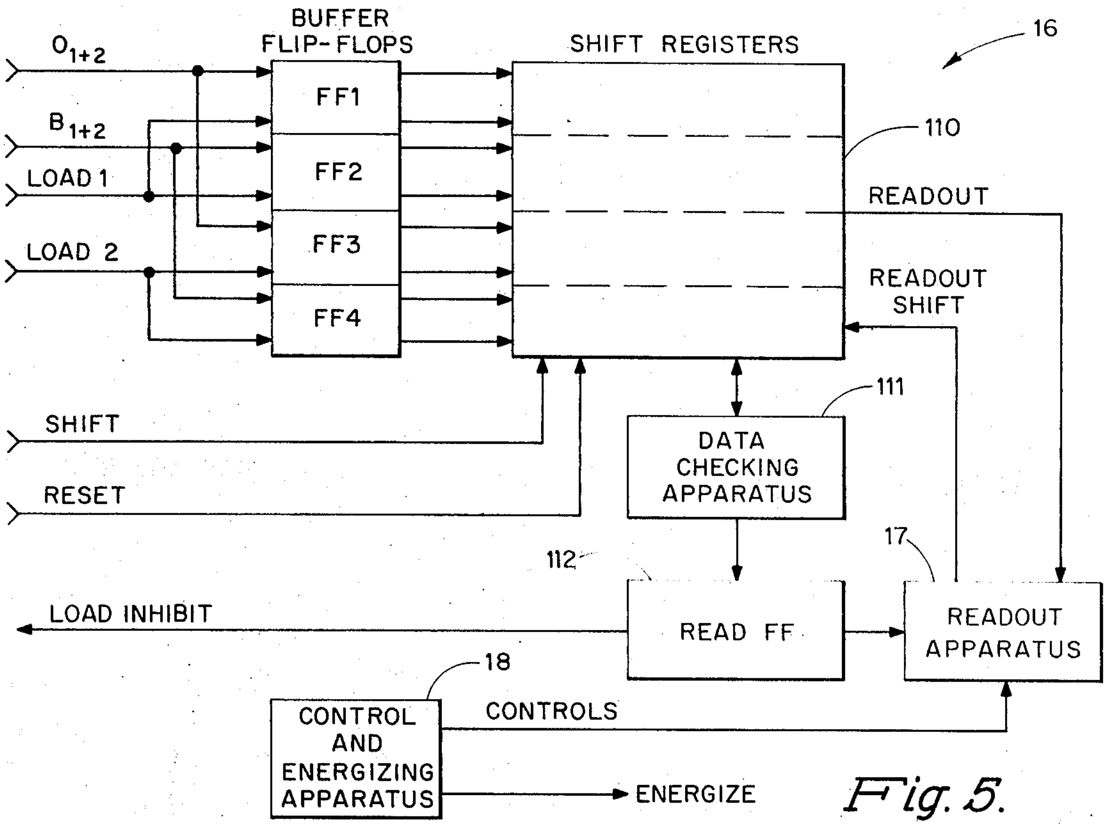

16
BUFFER FLIP-FLOPS
SHIFT REGISTERS
O_{1+2}
B_{1+2}
LOAD 1
LOAD 2
FF1
FF2
FF3
FF4
110
READOUT
READOUT SHIFT
SHIFT
RESET
111
DATA CHECKING APPARATUS
112
17
LOAD INHIBIT
READ FF
READOUT APPARATUS
18
CONTROL AND ENERGIZING APPARATUS
CONTROLS
ENERGIZE

Fig. 5.

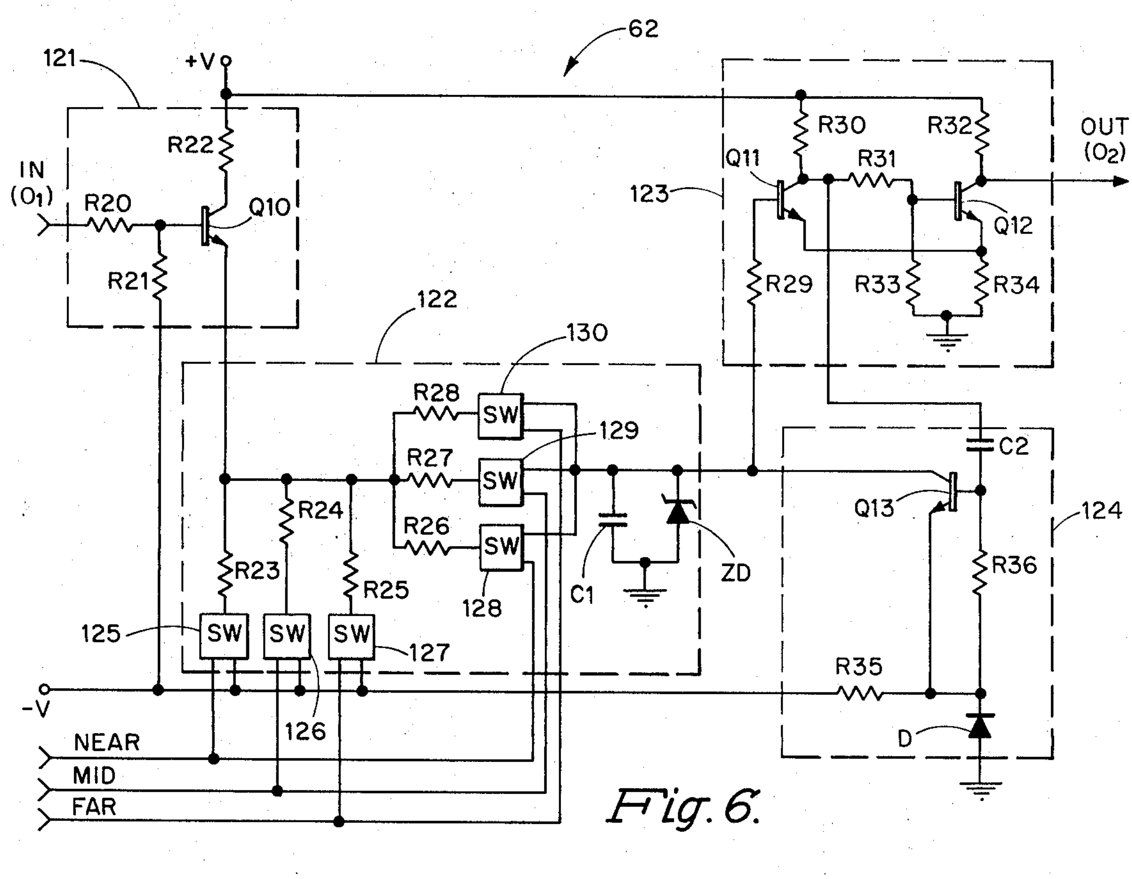

62
121
+V
IN (O_1)
R20
R21
R22
Q10
122
130
R28
R27
R26
SW
129
128
R24
R23
R25
125
126
127
C1
ZD
-V
NEAR
MID
FAR
123
R30
R32
R31
Q11
Q12
OUT (O_2)
R29
R33
R34
C2
Q13
124
R36
R35
D

Fig. 6.

SIGNAL PROCESSING SYSTEM FOR READING INDICIA OVER A WIDE DEPTH OF FIELD

BACKGROUND OF THE INVENTION

This invention relates to coded object identification systems. More particularly, it is concerned with automatic coded vehicle identification systems for reading labels on vehicles over a wide depth of field.

One well known coded object identification system for deriving information from coded retroreflective labels affixed to objects, for example, railway vehicles, is described in detail in U.S. Pat. No. 3,225,177 issued to Francis H. Stites and Raymond Alexander entitled "Mark Sensing". The system described in the patent is operative to read coded labels affixed to vehicles passing a scanning station and to decode the data content of these labels in order to ascertain the identity of the vehicles passing the scanning station. The labels are fabricated of stripes of colored retroreflective and black non-retroreflective material. Data is encoded in the labels in a two-position base-four code format by various two-stripe combinations of orange, blue, and white retroreflective and black non-retroreflective stripes to represent START and STOP control words and any combination of selected decimal digits 1 through 0. These individual stripes are of substantially equal widths and are mounted in a vertical succession of horizontally oriented stripes on the side of the vehicle, each two-stripe combination being separated from adjacent ones by a black spacer stripe. A significant feature of the code employed is the use of black non-retroreflective stripes as one of the four stripes of the code. The black stripes are used only as a second stripe in the two-stripe combinations because the system employs electrical pulses which are initiated by light reflected from the first stripe of every two-stripe combination, and the black stripes are essentially non-reflective.

To read a label passing a scanning station, a source of light at the scanning station is vertically scanned from bottom to top across the label, and light reflected from the label is received by the scanner and divided by a dichroic optical system into two light beams which are received by respective photosensors. One photosensor is responsive to orange light, while the other is responsive to blue light. Thus, the respective orange and blue photosensors are activated by light reflected from the orange and blue label stripes, and since light reflected from white stripes includes both orange and blue components, both photosensors are activated by light reflected from the white stripes. Neither photosensor is activated when a black non-reflective stripe is scanned.

Output signals from the orange and blue photosensors are converted to standardized pulses by respective standardizer circuits. Pulses from the standardizer circuits may then be appropriately modified and analyzed as in accordance with the system described and claimed in application Ser. No. 865,661, filed Oct. 13, 1969, by Christos B. Kapsambelis, Thomas P. Morehouse, Robert H. Reif, and Francis H. Stites entitled "Signal Processing System." In the system described in the application the leading and trailing edges of pulses from the standardizer circuits are employed to determine if the pulses meet certain pre-established criteria as to pulse-width and pulse-spacing. If these criteria,

which are satisfied by authentic data pulses, are met, loading signals are generated causing the pulses to be loaded into appropriate ones of a plurality of buffer flip-flops. When data pulses corresponding to a two-stripe combination have been stored in the buffer flip-flops, they are shifted into a plurality of shift registers. The data pulses are successively shifted along the shift registers until data derived from all the two-stripe combinations of a label have been stored in the shift registers. A further check is then made as to the authenticity of the accumulated data in the shift registers by employing pattern recognition and parity checking systems. If the stored label data passes the parity check, the accumulated data is transferred to readout apparatus for utilization.

As mentioned hereinabove, the individual stripes of a label are of equal widths. Thus, pulses generated when both stripes of a two-stripe combination reflect a color are twice the width of pulses generated when only one of the stripes reflects that color. Since the system must be able to detect whether a pulse is derived from scanning a single stripe or from scanning both stripes of a two-stripe combination, the maximum width of a pulse derived from scanning a single stripe located near the scanning unit must not be greater than twice the minimum width of a pulse derived from scanning a single stripe located farther from the scanning unit. Therefore, the maximum distance between the scanning unit and the label cannot be greater than twice the minimum distance.

Such a limitation in the depth of field of the system has not been found to be critical in the reading of coded labels affixed to railway vehicles by virtue of their being confined to tracks. However, this limitation does place restrictions on the reading of labels in certain non-rail applications, for example, in reading labels on cars, trucks, or buses travelling on a roadway or through tollbooth areas, or in reading labels on trucks or buses entering or leaving transportation terminals or depots.

A coded object identification system for providing an expanded depth of field is disclosed in U.S. Pat. No. 3,587,050 issued to Anthony C. Durante entitled "Coded Object Identification System and Signal Processing Means." Although systems in accordance with the patent operate satisfactorily, entire logic sections of the apparatus must be duplicated in order to analyze pulses derived from scanning labels located within two or more ranges of distances from the scanning unit.

SUMMARY OF THE INVENTION

The system in accordance with the present invention provides for reading labels within an expanded depth of field and checking their authenticity in accordance with the teachings of the aforementioned application of Kapsambelis et al with a minimum of duplications of elements of the apparatus. The system includes information sensing means for sensing the information encoded in a label and for producing a set of electrical signals representative thereof. Signal processing means which are coupled to the information sensing means process signals from the information sensing means in either a first or second predetermined manner depending upon whether a first or a second control signal is supplied thereto. A control signal is applied to the signal processing means by a processing control means which produces the first control signal for a first set of electrical signals whereby the first set of electrical signals is processed in the first predetermined manner and produces the second control signal for a second set of electrical signals whereby the second set of electrical signals is processed in the second predetermined manner.

The signal processing means, when operating to process signals in the first predetermined manner, optimally process signals produced by the information sensing means as a result of sensing information encoded in a label which is located within a first range of distances from the information sensing means. When operating to process signals in the second predetermined manner, the signal processing means optimally processes signals produced by the information sensing means as a result of sensing information encoded in a label which is located within a second range of distances from the information sensing means. Thus, when a label located within the depth of field of the apparatus as determined by the two ranges is subjected to two successive operations of the information sensing means, the data is processed twice. At least one of the processing operations will process the label data optimally with respect to the label distance. The number of ranges and consequently the number of different manners of processing data may be increased beyond two to provide a further expansion of the depth of field as desired for any particular application.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional objects, features, and advantages of systems for processing information encoded in a label in accordance with the present invention will be apparent from the following detailed description together with the accompanying drawings wherein:

FIG. **1** is a diagrammatic representation in block diagram form of an automatic coded vehicle identification system having a wide depth of field in accordance with the present invention;

FIG. **2** is a representation of an exemplary label of the type previously described and which is employed in the system of FIG. **1**;

FIG. **3** is a diagrammatic representation of a scanning unit and an electro-optical control arrangement together with a signal amplification arrangement which may be employed in the system of FIG. **1**;

FIG. **4** is a detailed block diagram of apparatus employed in the system of FIG. **1** for shaping signals generated in the scanning unit and for analyzing the signals to determine whether or not the proper timing relationships are present;

FIG. **5** is a representation in block diagram form of apparatus for further processing signals received from the apparatus of FIG. **4**; and

FIG. **6** is a detailed circuit diagram of an integrator Schmitt trigger circuit which may be employed for shaping signals in the apparatus of FIG. **4**.

DETAILED DESCRIPTION OF THE INVENTION

General Description

A block diagram of a coded vehicle identification system in accordance with the invention is illustrated in FIG. **1**. As shown in FIG. **1** the vehicle identification system includes an optical scanning unit **10** for vertically scanning a light beam across a coded retroreflective label **12** affixed to the side of a vehicle **11**. An exemplary form of a label **12** is shown in FIG. **2**. The label **12** includes a plurality of orange, blue, and white retroreflective stripes and black non-retroreflective stripes arranged in selected two-stripe combinations to represent the identity or other information pertaining to the vehicle.

As a vehicle bearing a coded retroreflective label, such as the label shown in FIG. **2**, is presented to the scanning unit **10**, the label is repeatedly scanned vertically from bottom to top by light from the scanning unit. Light reflected from the label is returned to and received by the scanning unit and selectively converted into coded electrical signals representative of the information encoded in the label. The return light is separated into "orange" and "blue" components by optics within the scanning unit **10** and applied to orange-responsive and blue-responsive photocells OPC and BPC, respectively.

In response to an orange stripe being scanned, the orange-responsive photocell OPC operates to produce an output signal, and in response to a blue stripe being scanned, the blue-responsive photocell BPC operates to produce an output signal. In response to a white stripe being scanned, both of the photocells OPC and BPC operate simultaneously to produce respective output signals. (White retroreflective light includes both an orange and a blue component). In response to a black non-retroreflective stripe being scanned, neither of the photocells OPC nor BPC operates to produce an output signal.

The portion of the vehicle identification system as described briefly hereinabove is described in greater detail in the aforementioned patent to Stites and Alexander.

The output signals from the orange-responsive and blue-responsive photocells OPC and BPC are applied to respective amplifiers **13**. The amplified signals O and B are then applied to respective signal shapers **14**. Standardizer circuitry in the signal shapers removes distortion from the electrical signals O and B to provide standardized pulses, either of a first width corresponding to both stripes of a two-stripe combination or of a second width corresponding to a single stripe, and representative of the information encoded in the label. The signal shapers **14** also include circuitry for delaying the leading and trailing edges of the standardized pulses.

These standardized pulses, designated O_1 and B_1, and the pulses modified by delaying, designated O_2 and B_2, are applied to signal analysis apparatus **15**. The signal analysis apparatus **15** analyzes the applied pulses to determine if their widths and timing sequence satisfy certain pre-established pulse-width and timing criteria for proper label-derived pulses. If the pulses are found to meet the pre-established criteria, data pulses O_{1+2} and B_{1+2}, which are combinations of the standardized pulses and the delayed standardized pulses, are loaded into storage and data checking apparatus **16**.

After all the data on a label has bee accumulated in the storage and data checking apparatus **16**, the stored data is checked by pattern recognition and parity checking systems to determine whether the accumulated data meets certain prescribed criteria for proper label-derived data. If the data is determined to be from proper label-derived pulses, decoded output signals representative of the data content of the label are caused to be transferred to the readout apparatus **17**.

In the system as described the orange-responsive and blue-responsive photocells OPC and BPC produce electrical signals which are amplified, modified, and analyzed in three different manners, at least one of which is appropriate depending upon whether the label **12** is within a near, mid, or far range of distances from the scanning unit **10.** As indicated in FIG. **3** there is a slight overlap in the ranges to insure that each label within the depth of field is processed appropriately at least once.

For each scanning operation of the label a photoresponsive unit PR mounted in the scanning unit **10** causes a signal to be produced by a detector circuit **19.** The signals from the detector circuit **19** are applied to a counter and decoder **20** where they are counted repeatedly through a count of 3 and the count is decoded to produce in succession NEAR, MID, and FAR control signals on appropriate lines. These control signals are applied to the amplifiers **13,** the signal shapers **14,** and the signal analysis apparatus **15,** and cause these sections of the system to process optimally signals derived from a label within either the near range, the mid range, or the far range. Thus, during three scanning operations of a label located within the depth of field established by the three ranges, the signals from the photocells OPC and BPC will be optimally processed at least once to determine if they meet all the criteria for proper label-derived signals. That is, if a label is within the depth of field, during one of three successive scanning operations the signals produced should be found to meet the pre-established criteria so that the data will be accepted and stored in the storage and data checking apparatus **16.** Signals which are processed other than optimally by virtue of the label being located in a range not corresponding to the control signal will fail to meet the pre-established criteria and therefore will not be accepted for storage in the data and storage checking apparatus **16.** When all the data on a label has been accumulated in the storage and data checking apparatus, it is checked in accordance with pattern recognition and parity checking schemes. This checking procedure is always carried out in the same prescribed manner independently of the range in which the label is located and the process control signals.

The system also includes control and energizing apparatus **18** which may be activated as by the entrance of a vehicle into the label reading area so as to energize the circuitry of the system and to control operation of the readout apparatus **17.**

Label

An exemplary form of a label employed in the system of FIG. **1** is illustrated in FIG. **2.** The label includes a plurality of orange, blue, and white retroreflective stripes and black non-retroreflective stripes arranged in selected two-stripe code combinations to represent the identity or other information pertaining to the vehicle. The coded retroreflective label is typically fabricated from a plurality of equal width rectangular, orange, blue, and white retroreflective stripes, and non-retroreflective black stripes. The orange, blue, and white retroreflective stripes have the capability of reflecting incident light directed thereon along the path of incidence whereas the black stripes effectively lack such a capability of retroreflection. The label **12,** as shown in FIG. **2,** is coded in a two-position base-four code format by various two-stripe combinations of the retroreflective orange, blue, and white stripes, and the non-retroreflective black stripes to represent desired information pertaining to the vehicle upon which the label is affixed. For purposes of illustration only, the label as shown in FIG. **2** is encoded to represent a START control word, a plurality of digits 8507913624, a STOP control word, and a parity check integer (**8**).

The coded stripe-pairs of the label are separated by black non-reflecting spacers and are surrounded on the edges by a black non-reflecting border. The purpose of the non-reflecting spacers is to isolate the stripe-pairs from each other so as to enable processing of the data encoded in the stripe-pairs. In coded vehicle identification systems as presently employed the vertical stripes are 6 inches long and three-eighths inch in vertical width for each individual stripe, and thus three-fourths inch for each stripe-pair, and the black non-reflecting spacers between the stripe-pairs are one-half inch in vertical width.

The value of the parity check integer corresponding to the shown combination of digits is calculated in accordance with a well known system of parity designated the "powers-of-two modulo-11" system. The proper value of the parity check integer as calculated in accordance with he system is 8. This system of parity is described in detail together with an apparatus for checking the information data read from the label against the parity integer in U.S. Pat. No. 3,524,163 to Henry N. Weiss entitled "Parity-Checking Apparatus for Coded Vehicle Identification Systems."

Scanning Unit, Signal Amplification, and Processing Control Arrangement

When a vehicle having a coded retroreflective label **12,** such as the label illustrated in FIG. **2,** affixed thereto is presented to the scanning unit **10** within a near, mid, or far range of distances from the scanning unit, as illustrated in FIG. **3,** the label is repeatedly scanned vertically from bottom to top by light from the scanning unit. The scanning unit **10** as shown in FIG. **3** includes a rotating wheel **33** having a plurality of reflective mirror surfaces **34** on its periphery, an optics assembly **35** including the aforementioned orange-responsive photocell OPC and blue-responsive photocell BPC, and a light source **36.** By way of example, the rotating wheel may be 14 inches in diameter, have 12 reflective surfaces on its periphery, and rotate at 1,200 revolutions per minute. In the operation of the scanning unit **10** as the vehicle bearing the label **12** is presented to the scanning unit within one of the ranges of the depth of field, light from the light source **36** is initially directed by the optics assembly **35** onto the reflective mirror surfaces **34** on the rotating wheel **33.** When a rotation motion is imparted to the rotating wheel **33** (as by a motor, not shown), the light received by the reflective mirror surfaces **34** is directed onto the label **12** through a transparent plastic or glass plate **37.**

The light directed onto the label is retroreflected by each of the retroreflective stripes of the label, as they are successively scanned, along the path of the incident light. The retroreflected light is returned by each retroreflective stripe, as it is scanned, onto the reflective mirror surfaces **34** of the rotating wheel **33** and then to the optics assembly **35.** In the optics assembly **35** the return light is separated into its orange and blue components and applied to the orange-responsive and blue-responsive photocells OPC and BPC, respectively. As mentioned previously, in response to an orange stripe being scanned, the orange-responsive photocell OPC is activated to produce an output signal, and in response to a blue stripe being scanned, the blue-responsive photocell BPC is activated to produce an output signal. In response to a white stripe being scanned, both of the photocells OPC and BPC are activated to produce respective output signals, and in response to a black non-retroreflective stripe being scanned, neither of the photocells OPC nor BPC is activated and no output signal is produced.

The output signals selectively produced by the photocells OPC and BPC are applied directly to respective amplifier circuits **13***a* and **13***b*. Operation of the amplifier circuits, which will be explained in detail hereinbelow, are controlled by processing control signals. As mentioned previously, NEAR, MID, and FAR control signals are produced in succession on appropriate control lines during succeeding scanning operations of the scanning unit **10.** The control signals may be produced as by the arrangement of photoresponsive devices PR1 and PR2, detector circuit **19,** and counter and decoder **20** as illustrated in FIG. **3.** As shown in FIG. **3,** the photoresponsive devices PR1 and PR2 are positioned on the glass or plastic plate **37** so as to be illuminated by the light directed toward the label **12** by each of the reflective mirror surfaces **34** in sequence. Preferably, the photoresponsive devices PR1 and PR2 are positioned on the plate **37** so as to be illuminated during the top portion or the bottom portion of each light scan provided by each reflective mirror surface **34.** The two photoresponsive devices PR1 and PR2, which may be solar cells, are connected in series opposition with the positive terminals being connected together and the negative terminals being connected to the light detector circuit **19.**

The negative terminal of the photoresponsive device PR1 is connected directly to ground and the negative terminal of the photoresponsive device PR2 is connected directly to the emitter of an NPN switching transistor Q1. The base of switching transistor Q1 is connected to the juncture of a pair of voltage divider resistors R1 and R2, the opposite end of the resistor R1 being connected to ground and the opposite end of the resistor R2 being connected to a positive voltage source B+. The collector of the switching transistor Q1 is coupled to the positive voltage source B+ through a resistor R3 and also directly to the base of an NPN transistor Q2 arranged in an emitter-follower configuration. The collector of the transistor Q2 is coupled to the positive voltage source B+ via a current limiting resistor R4, and its emitter is directly connected to a counter **31,** and resistor R50 to ground.

In the quiescent operating condition, the photoresponsive devices PR1 and PR2 are both exposed to ambient light conditions and any voltages developed across the photoresponsive devices PR1 and PR2 cancel each other because of their series opposing arrangement. Under these conditions, the voltage divider resistors R1 and R2 and the positive voltage source B+ maintain the base-emitter potential of the switching transistor Q1 at a positive value such that the transistor is forward biased in its conducting condition. With the switching transistor Q1 operating in its conducting condition, the base-emitter potential of the transistor Q2 is low and, accordingly, transistor Q2 is reverse-biased in its non-conducting condition. As a result, the emitter of the transistor Q2 is at approximately ground potential and the counter **31** is not actuated.

In the non-quiescent operating condition, as light from one of the reflective mirror surfaces **34** of the rotating wheel **33** illuminates instantaneously the first photoresponsive device **PR1,** as a label is scanned, a positive voltage is produced across the photoresponsive device PR1 (that is, the photoresponsive device PR1 acts like a positive battery source), and the potential at the emitter of the switching transistor Q1 becomes sufficiently positive with respect to the base so as to reverse bias transistor Q1 to its non-conducting condition. The base-emitter potential of the emitter-follower transistor Q2 accordingly becomes sufficiently positive to be forward biased into its conducting condition. As a result, the leading edge of a square-wave pulse is produced at the emitter of transistor Q2.

As the light from the reflective mirror surface **34** continues to move past the photoresponsive devices PR1 and PR2 such that both of the photoresponsive devices PR1 and PR2 are now simultaneously exposed, opposing voltages are produced across the photoresponsive devices PR1 and PR2 (that is, both of the photoresponsive devices PR1 and PR2 act as opposing positive and negative battery sources, respectively) and the opposing voltages cancel each other. As a result the transistors Q1 and Q2 are returned to their quiescent operating conditions and the trailing edge of a square-wave pulse is produced at the emitter of the emitter-follower transistor Q2.

As the light from the reflective mirror surface **34** moves past the first photoresponsive device PR1 such that only the second photoresponsive device PR2 is now illuminated, a negative voltage is developed across the photoresponsive device PR2. However, this negative serves only to render the voltage at the emitter of transistor Q1 more negative with respect to the base and to hold the transistor Q1 in its conducting condition.

Thus, with each scan of a label by each of the reflective mirror surfaces **34** of the rotating wheel **33,** a pulse is produced and applied to the counter **31.** The counter **31,** which may be a ring counter, is arranged to count through a recurring sequence of three states. The state of the counter **31** is detected by decoder gates **32** so as to produce in sequence NEAR, MID, and FAR control signals on the appropriate control lines. That is, for three successive scans NEAR, MID, and FAR control signals are produced in sequence. As will be explained hereinbelow these signals are employed to control operation of the apparatus so as to optimally process signals generated when a label is located within the corresponding range of the depth of field.

The electrical signals produced by the orange and blue responsive photocells OPC and BPC are amplified by amplifier circuits **13***a* and **13***b*, respectively. In order to process properly the output signals O and B from the amplifiers it is desirable that they be above a minimum detectable or threshold level and not exceed a maximum level whether the label is located within the near, mid, or far range. The least amplification is required for signals derived from labels located in the near range. Therefore, the amplification of the amplifier is controlled so as to be optimal for signals derived from a label within the range corresponding to the control signal.

Each amplifier circuit **13***a* and **13***b* is of the type shown and described in application Ser. No. 88,595 filed Nov. 12, 1970, by Frank G. Macey entitled "Amplifier Circuit Having a Controllable Gain." As described in this application the gain of an operational amplifier A1 or A2 is controlled by an appropriate value of control voltage at the juncture of feedback resistors R6 and R7 or R10 and R11. As illustrated in FIG. 3 two different voltage sources **42** and **43**, or **48** and **49** are connected in series with normally-open switches **45** and **46**, or **51** and **52** and resistors R51 and R52, or R53 and R54, respectively, to the junction. A MID or FAR control signal actuates one of the switches of each amplifier circuit applying a control voltage at the juncture of the feedback junction. The value of the applied control voltage is such that the amplifier circuits will amplify signals optimally to between he desired levels for a label located within the range corresponding to the applied control signal. The circuit component values are such that during a NEAR control signal when none of the switches are closed, the circuit amplifies optimally for signals derived from a label located in the near range. Since for three successive scans by the scanning unit three different control voltages are applied to each amplifier circuit in sequence, during one of the scans signals O and B which optimally amplified to within the desired levels for further processing will be produced. The switches may be any of various devices, such as, for example, a series-connected transistor which is normally non-conducting and is biased to conduction by the applied control signal.

Pulse Forming and Analyzing

Apparatus for shaping the O and B signals received from the amplifiers and for analyzing the resulting signals to determine whether or not they meet certain pre-established criteria is shown in detail in FIG. **4.** The O and B signals are applied to standardizer circuitry **61***a* and **61***b*, respectively, of the signal shapers **14.** The standardizer circuitry removes distortion and provides standardized pulses O_1 and B_1 of either a first width corresponding to both stripes of a stripe-pair or of a second width corresponding to a single stripe of a stripe-pair by detecting the widths of the signals between points of a predetermined amplitude. The standardizer circuitry may be of the type described in U.S. Pat. No. 3,229,271 issued to Francis H. Stites entitled "Electro-Optical Label Reading System Using Pulse Width Detection Circuit."

The standardized pulses O_1 and B_1 are applied to integrator Schmitt trigger circuits **62** and **63,** respectively, which operate to delay the leading edge of the standardized pulses by a predetermined first time duration and the trailing edge by a predetermined second time duration. The resulting pulses are designated O_2 and B_2, respectively. The purpose of providing delayed pulses is explained in the aforementioned application of Kapsambelis et al.

The integrator Schmitt trigger circuits **62** and **63** may be of the type described in U.S. Pat. No. 3,571,626 issued to Robert H. Reif entitled "Integrator Schmitt Trigger Circuit." This circuit may be modified as will be explained in detail hereinbelow, to provide variations in the predetermined time delays of both the leading and trailing edges of the applied pulses. In order to provide proper delays for pulses produced by scanning a label within the near, mid, or far range, the NEAR, MID, and FAR control signals are employed to set appropriate values thereby providing optimum delayed output pulses O_2 and B_2 during the control signal corresponding to the range in which the label is located.

The delayed pulses O_2 and B_2, either or both of them, are applied to an OR gate **67** of the signal analysis apparatus **15.** The output of the OR gate **67** is applied to one input of an AND gate **68.** The AND gate **68** also has an inverting input which is connected to a read flip-flop **112** (in the storage and data checking apparatus **16** illustrated in FIG. **5**). The normal condition of the read flip-flop **112** does not provide a LOAD INHIBIT signal. Thus the AND gate **68** is not inhibited, and the occurrence of either an O_2 or B_2 signal or both, indicating the first stripe of a stripe-pair, triggers a one-shot multivibrator **69.** The one-shot multivibrator **69** produces a short pulse (1 microsecond) providing a LOAD **1** signal to two buffer flip-flops FF1 and FF2 in the storage and data checking apparatus **16,** shown in FIG. **5,** causing to load therein for temporary storage, data pulses from the signal shapers **14.**

The data pulses presented to the buffer flip-flops FF1 and FF2 by the signal shapers **14** are combinations of the standardized pulses O_1 and B_1 and the delayed pulses O_2 and B_2, respectively. Pulses O_1 and O_2 are applied to an OR gate **64** and pulses B_1 and B_2 are applied to an OR gate **65** thereby producing stretched-out data pulses designated O_{1+2} and B_{1+2}, respectively. Thus, the data encoded in the first stripe of a stripe-pair is temporarily stored in buffer flip-flops FF1 and FF2.

During the time that pulses O_{1+2} and/or B_{1+2} are being produced in response to the first stripe of a stripe-pair being scanned and are loaded into the buffer flip-flops FF1 and FF2, pulse-width measurements are made to determine if pre-established pulse-width criteria for pulses derived from the single reflected stripe of a stripe-pair having a black second stripe are satisfied. If the pulses are acceptable as being derived from a single stripe, a LOAD **2** signal is produced after termination of the stretched-out pulses O_{1+2} and/or B_{1+2} causing "zeros" (indicating a black second stripe) to be loaded into a second pair of buffer flip-flops FF3 and FF4, shown in FIG. **5.**

If the pulses are determined not to be derived from the single stripe of a stripe-pair having a black second stripe, pulse-width measurements are made to determine if pre-established pulse-width criteria for pulses derived from both stripes of a stripe-pair are satisfied. If the pulses are acceptable as being derived from both stripes, a LOAD **2** signal is produced while pulses O_{1+2} and/or B_{1+2} derived by scanning the second stripe of the stripe-pair are present, thereby causing the data encoded in the second stripe to be temporarily stored in the buffer flip-flops FF3 and FF4.

The pulse-width measurements are performed by analyzing the standardized pulses O_1 and/or B_1 which are combined by an OR gate **66** and the standardized delayed pulses O_2 and/or B_2 which are combined by the OR gate **67.** The output pulse from the one-shot multivibrator **69,** initiated by a pulse O_2 and/or B_2 corresponding to the first stripe of a stripe-pair as mentioned previously, is applied through OR gate **72** to reset a single stripe flip-flop **72,** through OR gate **78** to reset a stripe-pair flip-flop **77,** to reset a shift enable flip-flop **80,** to reset a synchronous counter **82** to its cleared condition, and to set a counter enable flip-flop **84.**

Three crystal controlled oscillators **100, 101,** and **102** operate at three different frequencies f_N, f_M, and f_F, one of the frequencies being appropriate depending upon whether the pulses being analyzed are derived from a label within the near, mid, or far range. The crystal controlled oscillators **100, 101,** and **102** are connected through normally-open switches **97, 98,** and **99,** respectively, to a 100 nanosecond one-shot multivibrator **96.** Depending upon which control signal, NEAR, MID, or FAR, is produced by the decoder gates **32** (FIG. 3), one of the switches **97, 98,** or **99** is closed. The output of the associated crystal controlled oscillator **100, 101,** or **102** triggers the one-shot multiivbrator **96** at a constant rate to produce a train of pulses 100 nanoseconds wide with spacing determined by the oscillator frequency f_N, f_M, or f_F.

The pulses produced by the one-shot multivibrator **96** are gated through an AND gate **85** when the counter enable flip-flop **84** is in its set condition. The signals from the one-shot multivibrator **96** gated through the AND gate **85** are counted by the synchronous counter **82.**

Predetermined ones of the accumulated counts in the synchronous counter **82** after the counter starts counting from its cleared condition are sensed by an arrangement of count sensing gates **81.** In response to sensing these counts, appropriate timing signals, each of which is a pulse of short duration, are produced in succession at the outputs of the count sensing gates **81** for controlling the operations of various parts of the signal analysis apparatus **15.** The timing of the pulses is designated as t_1–t_6. The actual time duration between these pulses will vary depending upon the particular crystal controlled oscillator **100, 101,** or **102** connected to the one-shot multivibrator **96,** but the ratios of the time durations will be the same.

Timing signal t_1 which occurs a predetermined number of counts after starting of the synchronous counter **82** is applied to the single stripe flip-flop **72** setting that flip-flop and producing an output to the AND gate **74.** A second input to the AND gate **74** is obtained for a differentiator **71** which produces a pulse when the signal from the AND gate **68** terminates on the trailing edge of the standardized delayed pulse O_2 and/or B_2. A timing signal t_3 from the count sensing gate **81** is applied to the OR gate **73** resetting the single stripe flip-flop **72.** Thus, an output signal from the AND gate **74** occurrs on the trailing edge of a delayed pulse O_2 and/or B_2 only if that trailing edge occurs at a time after timing pulse t_1 and before timing pulse t_3. The timing pulses t_1 and t_3 provide a pulse-width test for a single stripe (that is, a stripe-pair with a black second stripe) such that pulses O_2 and/or B_2 which terminate before time t_1 and after t_3 do not meet the established criteria for a single stripe pulse and therefore fail to actuate the AND gate **74.**

When a signal derived from a signal stripe passes this pulse-width test, the output signal from the AND gate **74** passes through an OR gate **75** and triggers a one-shot multivibrator **76.** The one-shot multivibrator **76** produces a short pulse (1 microsecond) which is a LOAD **2** signal to the second pair of buffer flip-flops FF3 and FF4 (FIG. **5**). Since, in this instance, the stripe-pair being scanned includes only a single stripe (that is, the second stripe is black) and the O_2 and/or B_2 pulses derived from the single stripe have terminated, the LOAD **2** signal causes the flip-flops FF3 and FF4 to load "zeros".

The second timing signal t_2 from the count sensing gates **81** sets the stripe-pair flip-flop **77** which produces an output signal to AND gate **79.** The other input to the AND gate **79** is from the standardizer circuitry **61**_a_ and **61**_b_ through an OR gate **66** and a differentiator **70.** The differentiator **70** produces a pulse on the trailing edge of the O_1 and/or B_1 pulses from the standardizer circuitry. Timing signal t_5 from the count sensing gates **81** is applied through OR gate **78** to reset the stripe-pair flip-flop **77.** Thus, AND gate **79** produces an output signal on the trailing edge of the O_1 and/or B_1 pulse only if the stripe-pair **77** is in a set condition. That is, if the O_1 and/or B_1 pulse terminates after the occurrence of timing signal t_2 but before the occurrence of timing signal t_5, AND gate **79** produces an output signal. The output signal from the AND gate **79** passes through OR gate **75** triggering the one-shot multivibrator **76** and producing a LOAD **2** signal to the second pair of buffer flip-flops FF3 and FF4 (FIG. **5**). Since the portion of the stretched-out version of the pulses O_{1+2} and/or B_{1+2} which are derived from the second stripe of the stripe-pair have not yet terminated, the pulse data is loaded into buffer flip-flops FF3 and FF4. Thus, pulses which are derived from scanning both stripes of a stripe-pair are tested to determine that the pulses meet the pre-established pulse-width criteria, and the data encoded in the second stripe is entered in the buffer flip-flops for temporary storage.

After the pulses corresponding to a given stripe-pair of a label have been stored in the buffer flip-flops **FF1-FF4,** that is, after the termination of a LOAD **2** signal (produced as a result of the operation of either AND gate **74** or AND gate **79**), the pulses are retained in the buffer flip-flops **FF1-FF4** for a predetermined time duration for the purpose of performing an additional check on the pulses to further determine whether the pulses are proper label-derived pulses. It has been determined that if noise is present in the system it generally precedes the data within a certain period of time. Therefore, if new pulses are received within this predetermined period after pulses have been stored in the buffer flip-flops, the pulses present in the flip-flops are considered to be noise and are prevented from being further processed. Instead, the new pulses are processed in the same manner as previously described and loaded into the buffer flip-flops to replace the previous pulses. If no new pulses are received during the predetermined period, the pulses stored in the buffer flip-flops are further processed.

This check on whether the stored pulses are proper label data pulses or noise is performed in the following manner. The LOAD **2** signal from the one-shot multivibrator **76** triggers three one-shot multivibrators **86, 87,** and **88** which produce relatively long output pulses (of the order of 10 to 20 microseconds, for example). The duration of the output pulses from the multivibrators **86, 87,** and **88,** designated T_N, T_M, and T_F, are set to be appropriate to provide the optimal time period depending on whether the label is within the near, mid, or far range, respectively. Therefore, the output pulse of only one of the three one-shot multivibrators **86, 87,** and **88** is applied to a differentiator **92.** The particular multivibrator is selected by which of the normally-open switches **89, 90,** or **91** is closed by a NEAR, MID, or FAR control signal, respectively. The differentiator **92** produces an output pulse on the trailing edge of the relatively long time duration pulse from the selected one-shot multivibrator **86, 87,** or **88.** The output of the differentiator **92** is applied to an AND gate **93.**

The other input to the AND gate **93** is the output from the shift enable flip-flop **80.** The shift enable flip-flop **80** is previously triggered to the set condition at an appropriate time by a t_4 timing signal rom the count sensing gates **81.** The shift enable flip-flop **80** is reset by the one-shot multivibrator **69** as it produces a LOAD **1** signal on the receipt of new signals indicating a stripe-pair. Thus, the AND gate **93** produces an output signal on the trailing edge of the pulse from the selected multivibrator **86, 87,** or **88** only if the trailing edge occurs before the occurrence of signals indicating a stripe-pair is being scanned. The delay in producing the signal provides sufficient time to further insure that the data stored in the buffer flip-flops FF1-FF4 is label-derived data and not noise preceding proper label data.

An output signal from the AND gate **93** triggers a one-shot multivibrator **94** which produces a short duration (1 microsecond) SHIFT signal. The SHIFT signal causes the pulses stored in the buffer flip-flops FF1–FF4 to be shifted into the shift registers **110** (FIG. **5**) and any data previously loaded in the shift registers to be shifted one stage.

An additional time check is also performed by the apparatus employing the timing signal t_6 from the count sensing gates **81.** Timing signal t_6 occurs later than the expected occurrence of the leading edge of the pulse O_2 and/or B_2 derived from the first stripe of the next following stripe-pair of the label being scanned. The t_6 timing signal is applied to the shift registers **110** (FIG. **5**) by way of a differentiator **95** and to the counter enable flip-flop **84** by way of an OR gate **83.** Thus, if the synchronous counter **82** is not reset to its cleared condition by the one-shot multivibrator **69** producing a LOAD **1** signal before the t_6 timing signal, a t_6 signal will occur causing the shift registers **110** to be reset to all "zeros" and the synchronous counter **84** to be reset thereby stopping the synchronous counter **82.** That is, the resetting operation initiated by timing signal t_6 takes place only if the time between data signals does not meet the pre-established criteria for spacing between stripe-pairs of the label.

Data Checking and Readout

The data encoded in a pair of stripes of the label is thus stored in the appropriate buffer flip-flops FF1–FF4 (FIG. **5**) while the stripes are being scanned by the scanning unit as explained hereinabove. The data is removed from the buffer flip-flops FF1–FF4 and shifted through the stages of the four shift registers **110** in the general manner described, for example, in the aforementioned patent to Stites and Alexander, by SHIFT pulses from the one-shot multivibrator **94.** After the data of an entire label has been loaded into the shift registers **110,** it is checked for completeness and accuracy by suitable data checking apparatus **111.** The data checking apparatus may employ any of various known pattern recognition techniques, such as identifying the presence of the START and STOP words in the proper register stages. (See, for example, the aforementioned patent to Stites and Alexander or U.S. Pat. No. 3,417,231 issued to Francis H. Stites and Bradstreet J. Vachon, entitled "Mark Sensing System".) The accumulated data is also checked against the parity check integer in accordance with a particular parity checking scheme such as that described in the aforementioned patent to Weiss.

When the data checking apparatus **111** has determined that the data stored in the shift registers meets the pre-established criteria and relates to valid label data, it produces an output signal to the read flip-flop **112.** The read flip-flop **112** changes states to produce a LOAD INHIBIT signal which inhibits the AND gate **68** and also resets the counter enable flip-flop **84** by way of the OR gate **83** so as to prevent continued operation of the synchornous counter **82.** The read flip-flop **112** also signals the readout apparatus **17** to cause a READOUT SHIFT signal to be applied to the shift registers **110** whereby the accumulated contents of the shift registers is transferred to the readout apparatus **17.** Clearing of the data from the shift registers **110** causes the read flip-flop **112** to be reset removing the LOAD INHIBIT signal and placing the apparatus in readiness for receiving data during the next operation of the scanning unit.

Integrator Schmitt Trigger Circuit

The integrator Schmitt trigger circuits **62** and **63** as described briefly hereinabove are described in detail in the aforementioned patent to Reif. The circuit **62** for providing different delays for the delayed pulse O_2 in response to the standardized pulse O_1 is shown in detail in the circuit diagram of FIG. **6.** The circuit operates in the manner described in the patent to Reif, and as explained therein delays in the leading and trailing edges of the output pulses with respect to those of the input pulses are determined by the values of resistances in the integrator section **122.** The leading edge delay is determined by selecting one of resistances **R26, R27,** and **R28** and the trailing edge delay is determined by selecting one of resistances **R23, R24,** and **R25.**

Resistances R23, R24, and R25 are connected in series with normally-open switches **125, 126,** and **127,** respectively, and resistances **R26, R27,** and **R28** are connected in series with normally-open switches **128, 129,** and **130,** respectively. The NEAR, MID, and FAR control signals are applied to switches **125** and **128, 126** and **129,** and **127** and **130,** respectively, to close the appropriate switches. Thus, appropriate values of resistances are placed in the circuit for providing optimum values of delay for processing data derived from labels in the near, mid, and far ranges during the corresponding control signal.

Summary of Operation

For exam scan of the light beam across a label, signals are produced, shaped, and analyzed by the apparatus as explained hereinabove. By virtue of the control signals which are produced in sequence, a different one during each scanning operation in three successive operations, the signals derived from the label are processed in three different predetermined manners, at least one of which is optimum for the label depending upon its distance from the scanning unit. Thus, during at least one of three scanning operations the data is processed in an appropriate manner for its location.

The apparatus may be modified to cover a greater depth of field by increasing the number of different ranges of distance and processing procedures to more than three. Conversely, in certain situations two ranges and processing procedures may be sufficient. In any event, the number of elements of the system which must be duplicated are kept at a minimum by only altering those elements which determine the values of the prescribed limits to which the pulses are to be measured.

The following table is an example of specific values applicable to a system for reading labels having a single stripe width of three-eighths inch and a spacing between the stripe-pairs of one-half inch and covering a depth of field from 5 to 15 feet in three ranges. The scanning wheel includes 12 mirror surfaces and rotates at 1,200 revolutions per minute.

	Near Range	Mid Range	Far Range
Distance from Scanner to Label (Nominal)	5–8 ft.	8–11 ft.	11–15 ft.
Time Duration			
Single Stripe - Min.	13.9 μs	10.3 μs	8 μs
Single Stripe - Max.	25.7 μs	16.1 μs	11.7 μs
Two-Stripe Combination - Min.	30.3 μs	22 μs	17.3 μs
Two-Stripe Combination - Max.	53.2 μs	33.3 μs	24.3 μs
Spacer - Min.	20.2 μs	14.7 μs	10.4 μs
Spacer - Max.	83 μs	52 μs	38 μs
Signal Amplification by Amplifiers	6 db	18 db	30 db
Pulse Delay by Integrator Schmitt Trigger Circuits			
Leading Edge	5.8 μs	4 μs	2.9 μs
Trailing Edge	10 μs	7 μs	5.1 μs
Crystal Controlled Oscillator	f_N=2.9 Mhz	f_M= 4 Mhz	f_F=5.4 Mhz
Multivibrator Pulse Duration	T_N= 18 μs	T_M= 13 μs	T_F=9.6 μs

While there has been shown and described what is considered a preferred embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention as defined in the appended claims.

What is claimed is:

1. A system for processing information encoded in a label affixed to an object, said label comprising a plurality of radiation-reflecting code elements arranged in accordance with a predetermined code format to represent information pertaining to the object, said label being presented by said object to an information sensing means at a distance from the information sensing means; said system comprising

information sensing means for repeatedly sensing the information encoded in the plurality of radiation-reflecting elements of a label presented thereto and for producing sets of electrical signals representative of the information encoded in the plurality of radiation-reflecting elements of the label, said information sensing means including

scanning means for repeatedly scanning the radiation-reflecting elements of the label with an incident beam of electromagnetic radiation; and

means arranged to receive electromagnetic radiation reflected from the radiation-reflecting elements and operable in response to electromagnetic radiation received after reflection from the radiation-reflecting elements to produce a set of electrical signals representative of the information encoded in the plurality of radiation-reflecting elements of the label during each operation of the scanning means to scan the raditaion-reflecting elements of the label;

signal processing means including pulse-width detection circuit means operable to measure the widths at predetermined amplitude points of the signals received from the information sensing means and means operable to process signals produced by the information sensing means in a first predetermined manner in response to a first control signal being applied thereto and to process signals produced by the information sensing means in a second predetermined manner in response to a second control signal being applied thereto; said signal processing means when operating to process signals in the first predetermined manner optimally processes signals produced by the information sensing means when a label is presented thereto within a first range of distances therefrom, and said signal processing means when operating to process signals in the second predetermined manner optimally processes signals produced by the information sensing means when a label is presented thereto within a second range of distances therefrom;

means coupling said information sensing means and said signal processing means;

additional signal processing means including

storage means coupled to the signal processing means for storing a set of signals from the signal processing means; and

signal checking means coupled to the storage means for examining signals stored in the storage means to determine whether said signals satisfy certain pre-established criteria and operable to cause the signals stored in the storage means to be read out from the storage means if the signals stored therein satisfy said pre-established criteria; and

processing control means coupled to the information sensing means and to the signal processing means and operable in response to successive operations of the scanning means to scan the plurality of radiation-reflecting elements of a label presented thereto to produce the first control signal and the second control signal in succession.

2. A system in accordance with claim **1** wherein said signal processing means includes

pulse-width checking means coupled to the pulse-width detection circuit means and to said storage means and operable to determine whether the measured signal widths are within prescribed limits and to cause signals received from the information sensing means to be stored in the storage means when the measured signal widths are determined to be within the prescribed limits;

said pulse-width checking means including means coupled to the processing control means and operable to establish a first set of values for said prescribed limits when the first control signal is being produced by the processing control means and to establish a second set of values for said prescribed limits when the second control signal is being produced by the processing control means.

3. A system in accordance with claim **2** wherein said processing control means includes

first circuit means coupled to the scanning means and operable to produce an output signal in response to each operation of the scanning means to scan the radiation-reflecting elements of a label; and

second circuit means operable in response to each output signal from the first circuit means to change the output of the processing control means from one control signal to another control signal.

4. A system in ccordance with claim **3** including

an amplifying means connected between said means of the information sensing means and said signal processing means for amplifying electrical signals produced by said means; and

amplifying control means coupled to said amplifying means and to said processing control means and operable to cause said amplifying means to amplify signals applied thereto by a first amount in response to the first control signal being applied thereto and by a second amount in response to the second control signal being applied thereto; electrical signals produced by said means while the scanning means is scanning the radiation-reflecting elements of a label presented thereto within the first range of distances being amplified to within predetermined levels when amplified by said first amount and electrical signals produced by said means while the scanning means is scanning the radiation-reflecting elements of a label presented thereto within the second range of distances being amplified to within substantially the same predetermined levels when amplified by said second amount.

5. A system in accordance with claim **4** wherein

the radiation-reflecting elements of a label are selected from retroreflective stripes of a first color, a second color, and a third color, and non-reflecting stripes of a fourth color, said stripes being arranged in a vertical array of paired combinations of stripes with each pair being separated vertically by a non-reflecting spacer; and

the electromagnetic radiation is visible light.

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